

Lifetimes of excited states in neutron-rich nuclei

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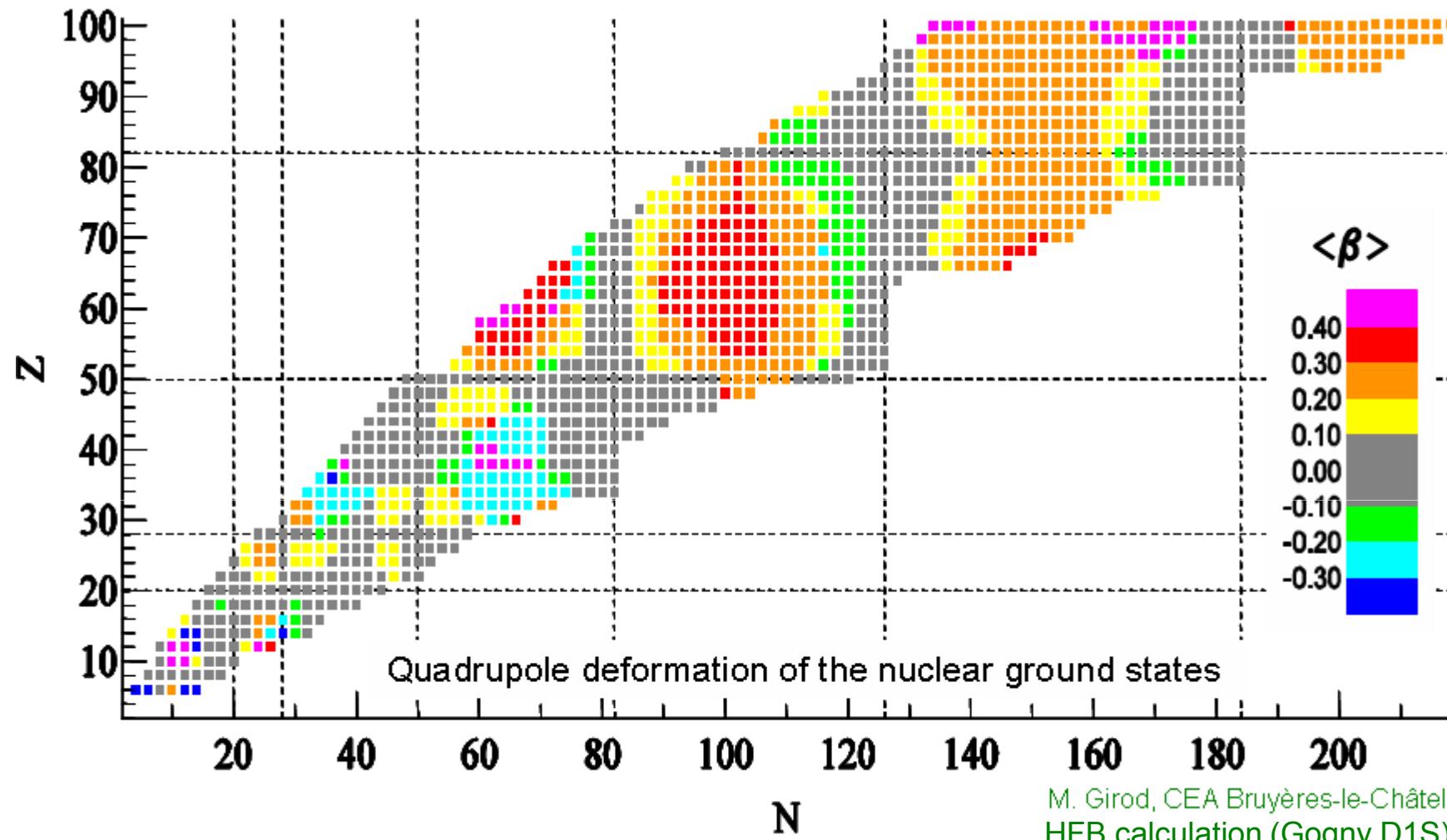
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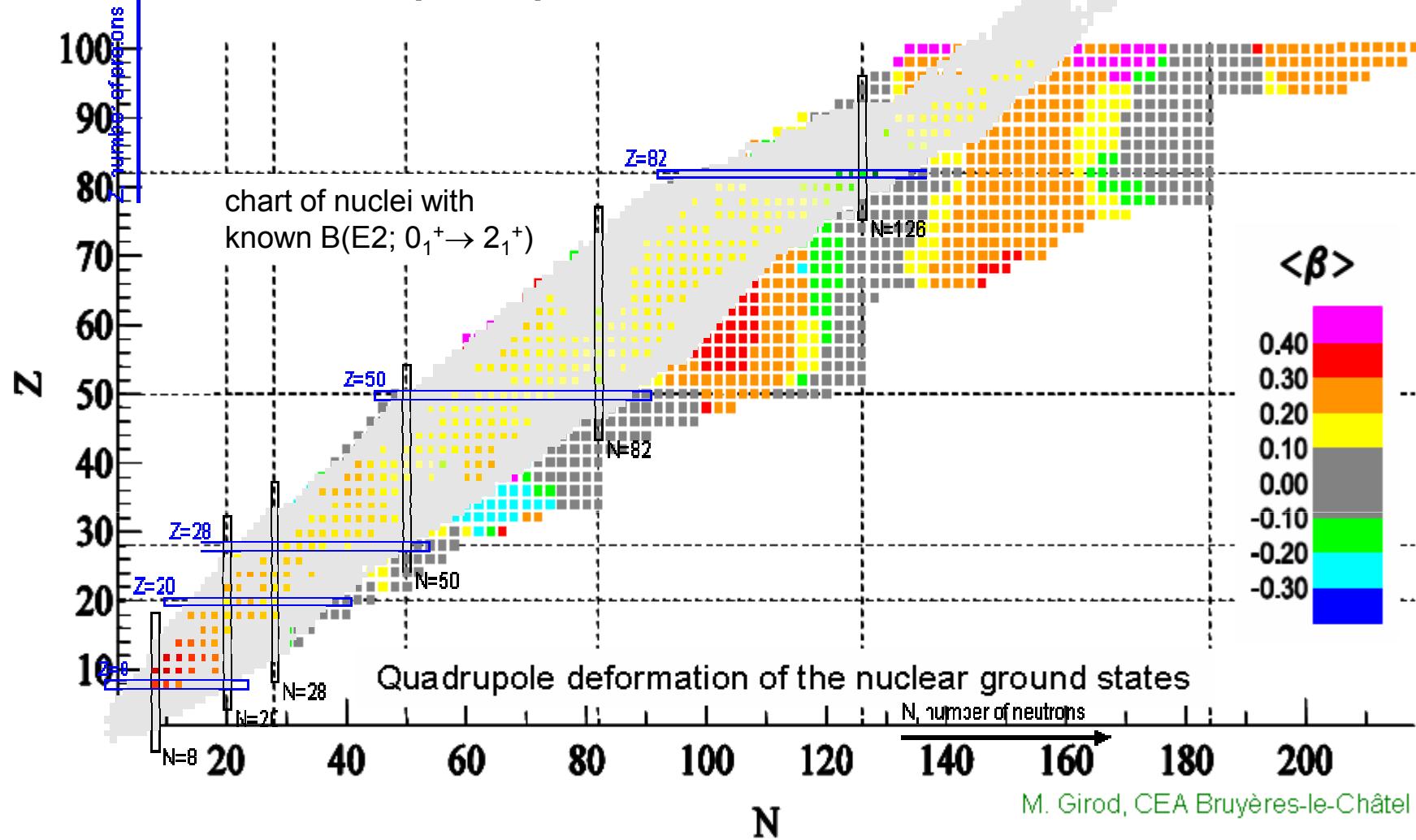
The nuclear chart of quadrupole deformation



deformed, open-shell nuclei:
➤ rapid shape changes
and shape coexistence

nuclei near shell closures:
➤ changes in the shell structure
for nuclei far from stability

The nuclear chart of quadrupole deformation

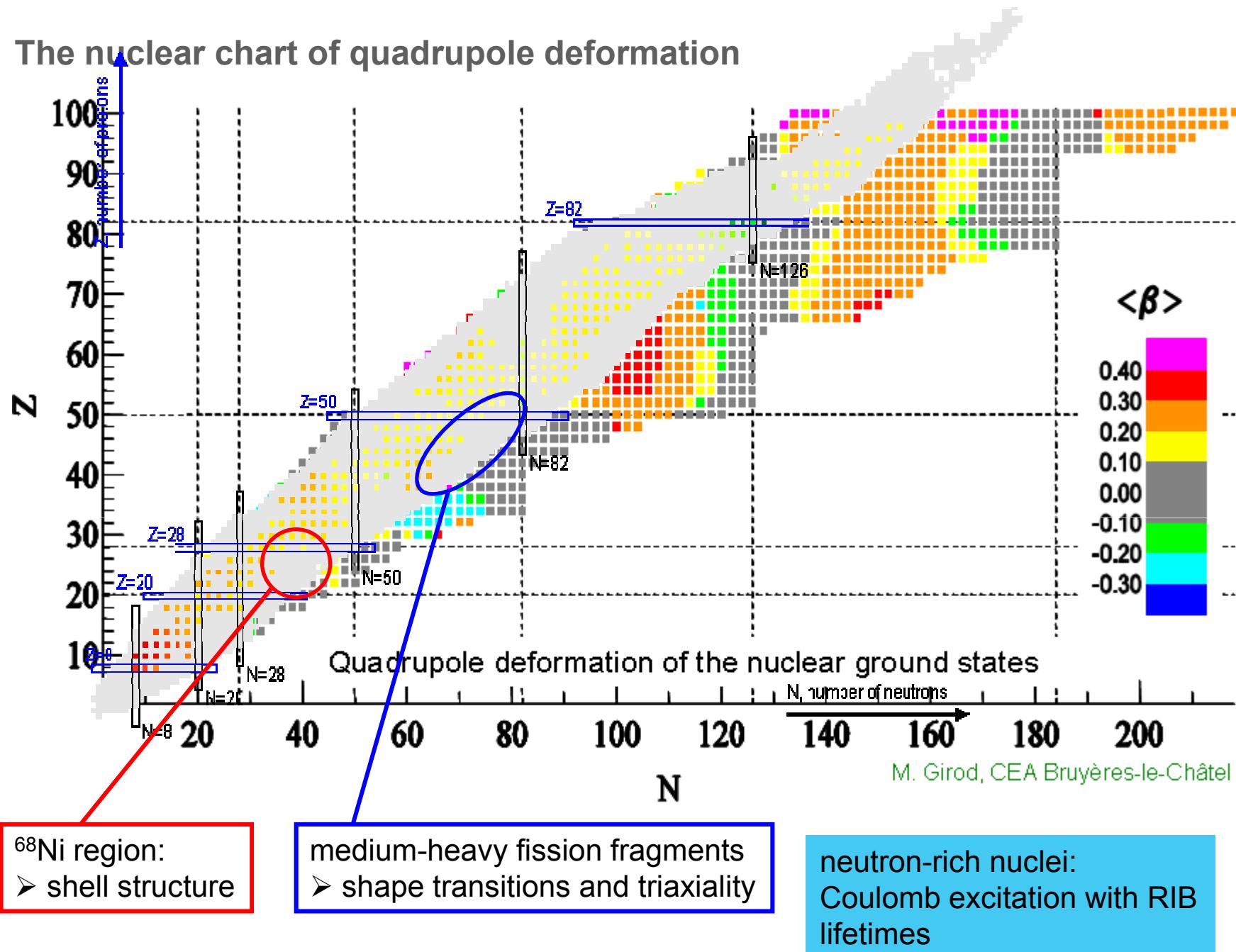


neutron-deficient nuclei:
(mostly) lifetime measurements
after fusion evaporation reaction

stable nuclei:
(mostly) Coulomb
excitation

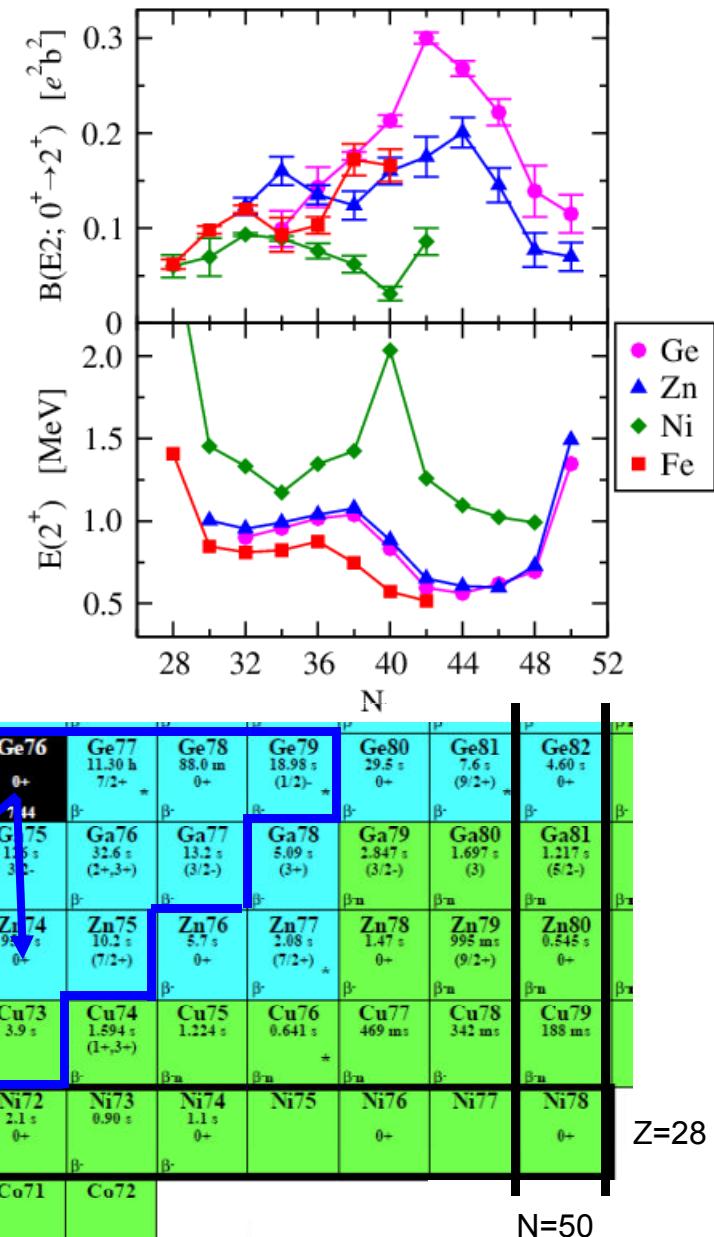
neutron-rich nuclei:
Coulomb excitation with RIB
lifetimes

The nuclear chart of quadrupole deformation



Collectivity around ^{68}Ni

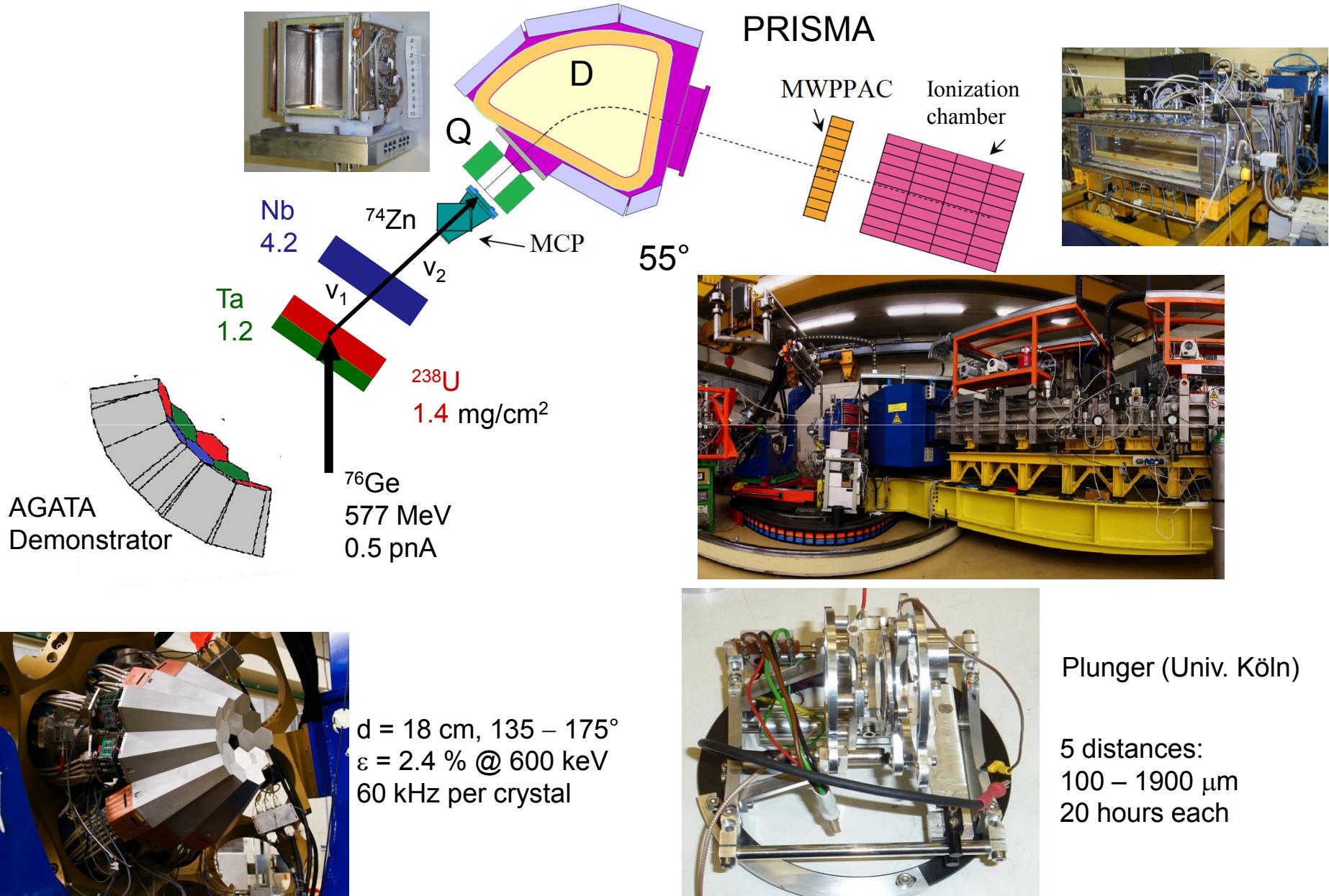
- N=40 sub-shell closure at ^{68}Ni
- $\pi-\nu$ correlations stronger than N=40 gap for $Z \neq 28$
- increased collectivity with filling of $\nu g_{9/2}$
- Lifetime measurements after multi-nucleon transfer
 - $^{238}\text{U} + ^{64}\text{Ni}$ with EXOGAM+VAMOS at GANIL
J. Ljungvall et al., PRC 81, 061301(R) (2010)
 - A. Dijon et al., PRC 83, 064321 (2011)
- $^{76}\text{Ge} + ^{238}\text{U}$ with AGATA+PRISMA at Legnaro



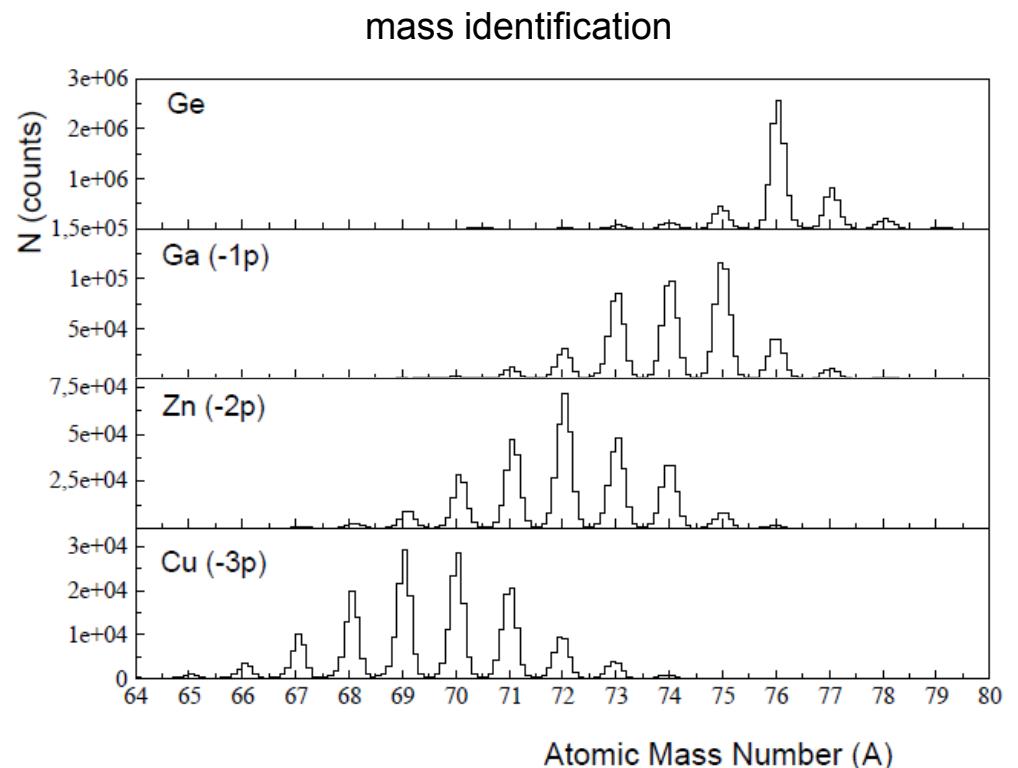
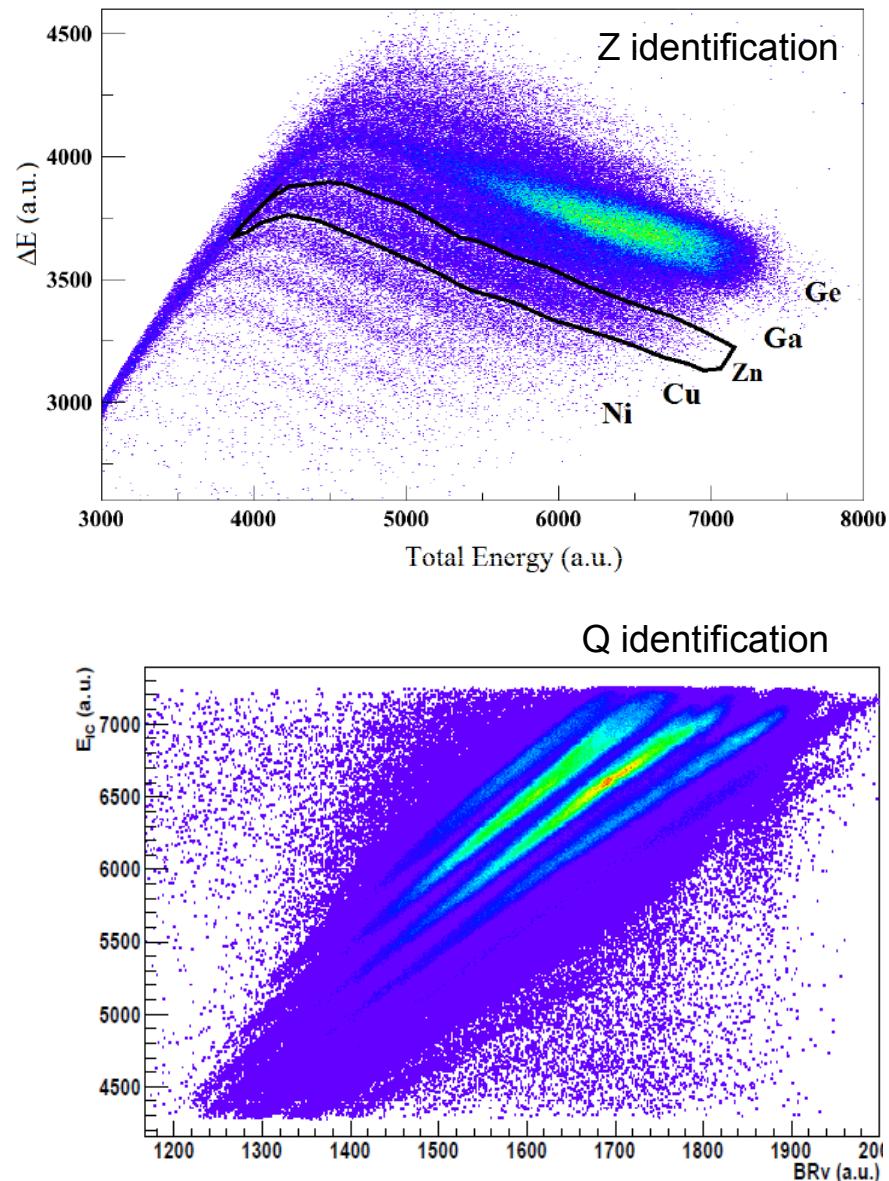
| | Ge^{65} | Ge^{66} | Ge^{67} | Ge^{68} | Ge^{69} | Ge^{70} | Ge^{71} | Ge^{72} | Ge^{73} | Ge^{74} | Ge^{75} | Ge^{76} | Ge^{77} | Ge^{78} | Ge^{79} | Ge^{80} | Ge^{81} | Ge^{82} | |
|---|------------------|------------------|------------------|------------------|------------------|-------------------------|------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|---------------------|--------------------|-------------------|-------------------|
| 4 | 30.9 s (3/2)- | 2.26 h 0+ | 18.9 m 1/2- | 270.8 d 0+ | 39.05 h 5/2- | 21.23 0+ | 11.43 d 1/2- | 21.23 0+ | 9/2+ * | 0+ | 82.78 m 1/2- * | 0+ | 11.30 h 7/2+ * | 11.30 h 7/2+ * | 88.0 m 0+ | 18.98 s (1/2)- * | 29.5 s 0+ | 7.6 s (9/2)- * | 4.60 s 0+ |
| 3 | 2.627 m 0+ | 15.2 m 3/2- | 9.49 h 0+ | 3.2612 d 3/2- | 67.629 m 1+ | 60.108 EC, β^- | 21.14 m 1+ | 27.66 3/2- | 21.14 m 3/2- | 35.94 3/2- | 8.12 s 3/2- | 14.10 h 3- * | 4.86 h 3/2- | 8.12 s 3/2- | 14.10 h 3- * | 32.6 s (2+, 3+) | 13.2 s (3/2-) | 5.09 s (3/2-) | 1.217 s (5/2-) |
| 2 | 38.47 m 3/2- | 15.2 m 0+ | 244.26 d 5/2- | 0+ | 5/2- | 48.6 EC | 27.9 EC | 27.9 EC | 56.4 m 0+ | 5E+14 y 1/2- * | 5.088 m 1+ | 61.83 h 3/2- | 31.1 s 1+ | 5.088 m 3/2- | 61.83 h 3/2- | 2.85 m (1+, 2-) | 2.85 m (1+, 2-) | 1.95 s (3/2-) | 1.95 s (3/2-) |
| 1 | 9.74 m 1+ | 3/2- | 12.001 h 1+ | 3/2- | 3/2- | 69.17 EC | 4.1 EC | 4.1 EC | 95.7 s 0+ | 95.7 s 0+ | 95.7 s 0+ | 95.7 s 0+ | 95.7 s 0+ | 95.7 s 0+ | 10.2 s (7/2+) | 10.2 s (7/2+) | 1.224 s 0+ | 1.224 s 0+ | |
| 0 | 1.140 3/2- | 3.634 0+ | 100.1 y 1/2- | 0+ | 0.940 0+ | Fe61 3/2- 1.140 | Fe62 0+ | Fe63 0+ | Fe64 0+ | Fe65 0+ | Fe66 0+ | Fe67 0+ | Fe68 0+ | Fe69 0+ | Fe70 0+ | Fe71 0+ | Fe72 0+ | Fe73 0+ | |
| | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | |

Z=28 N=50

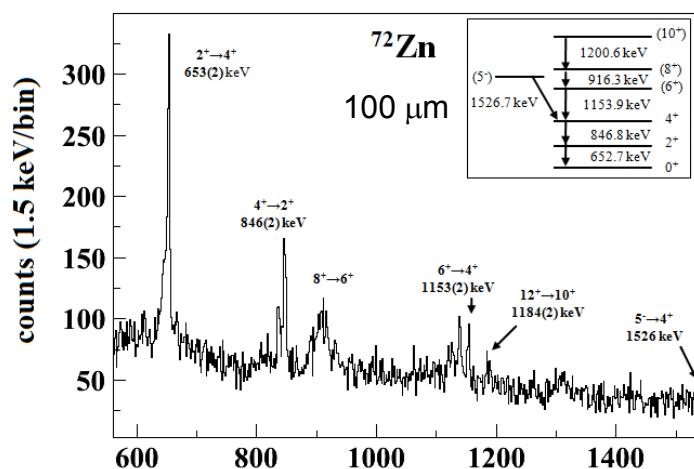
Lifetime measurement with AGATA Demonstrator



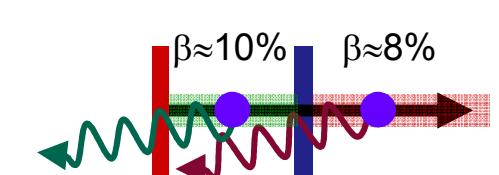
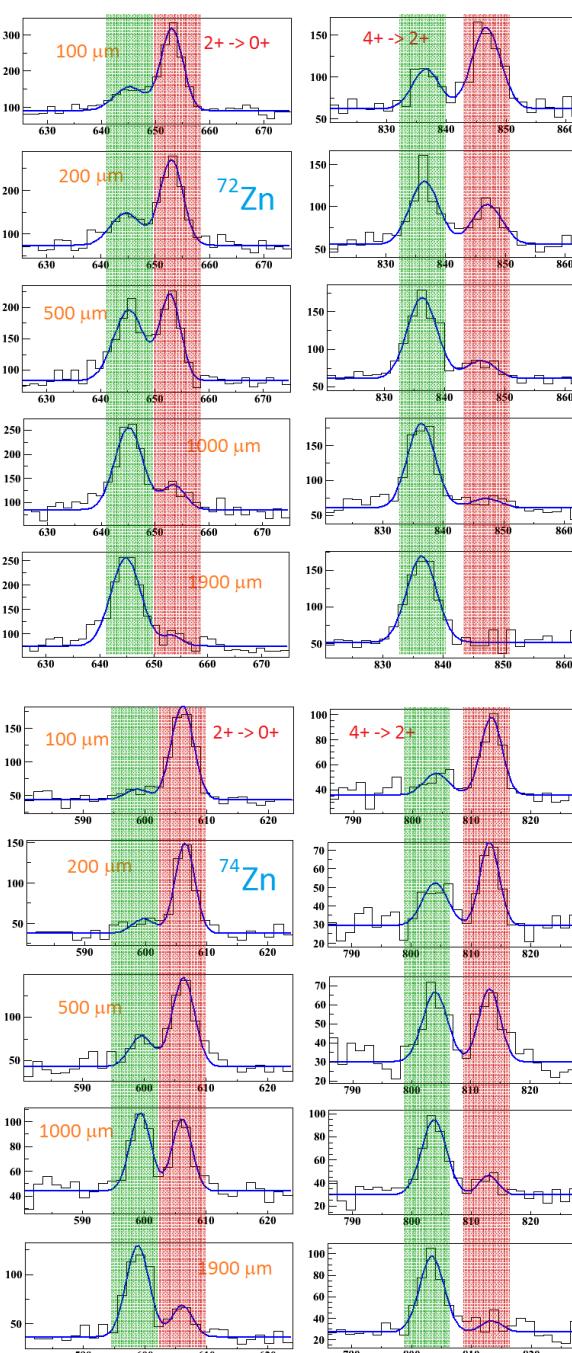
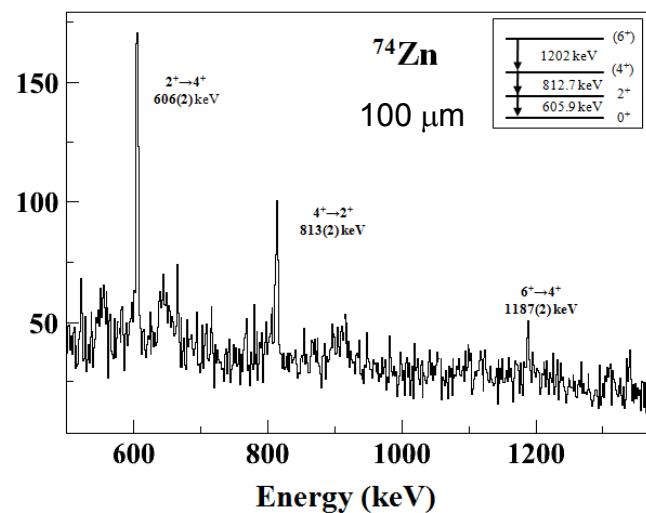
Identification in PRISMA



RDDS spectra



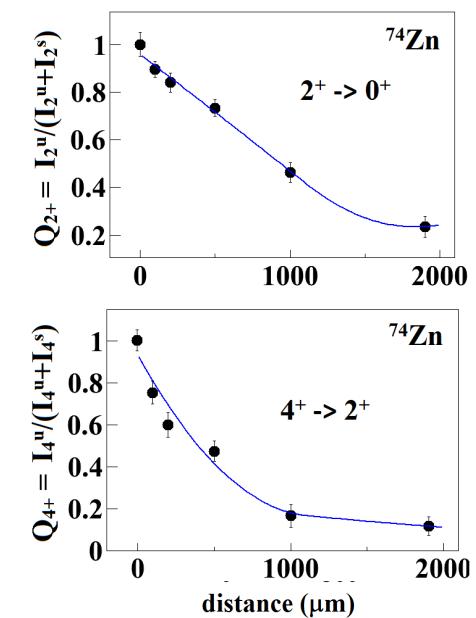
C. Louchart et al.
to be published



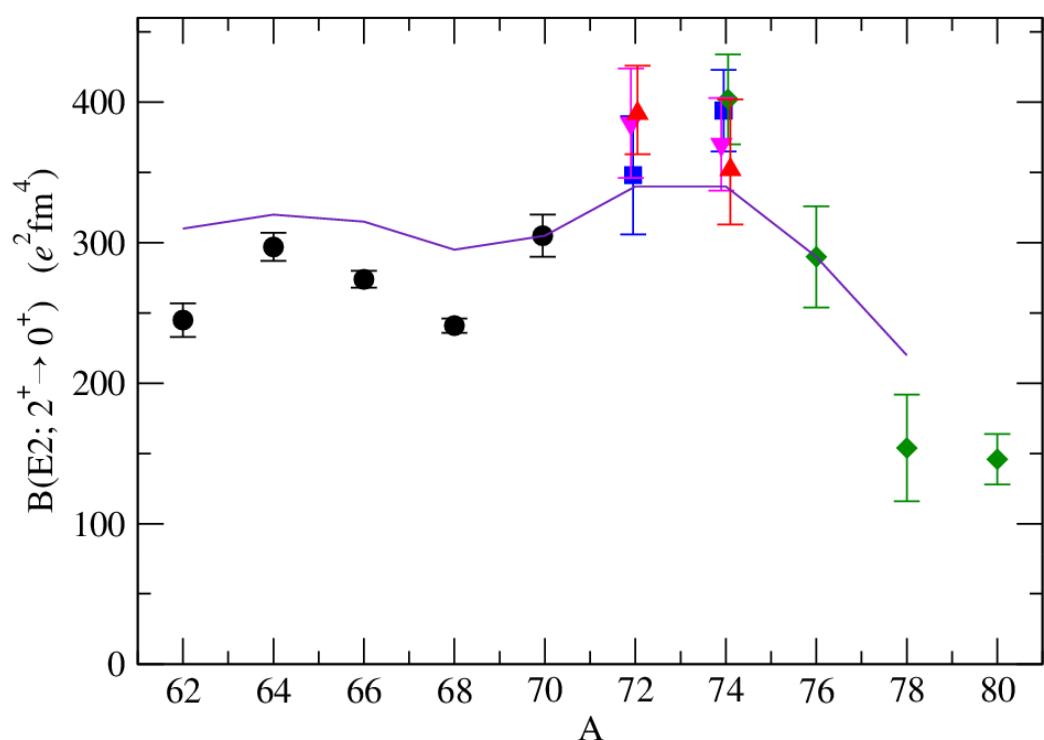
$$\tau_i(x) = -\frac{Q_i(x) - \sum_k \alpha_k Q_k(x)}{v * \frac{dQ_i}{dx}(x)}$$

$$Q_i = \frac{I_i^u}{I_i}$$

$$I_i = I_i^u + I_i^s$$

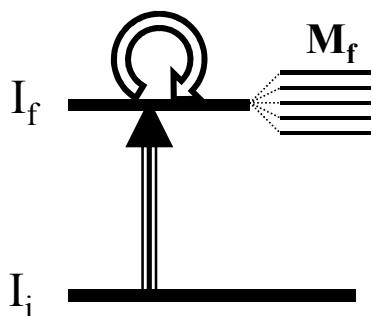


Systematics of $B(E2; 2^+ \rightarrow 0^+)$ values for Zn isotopes



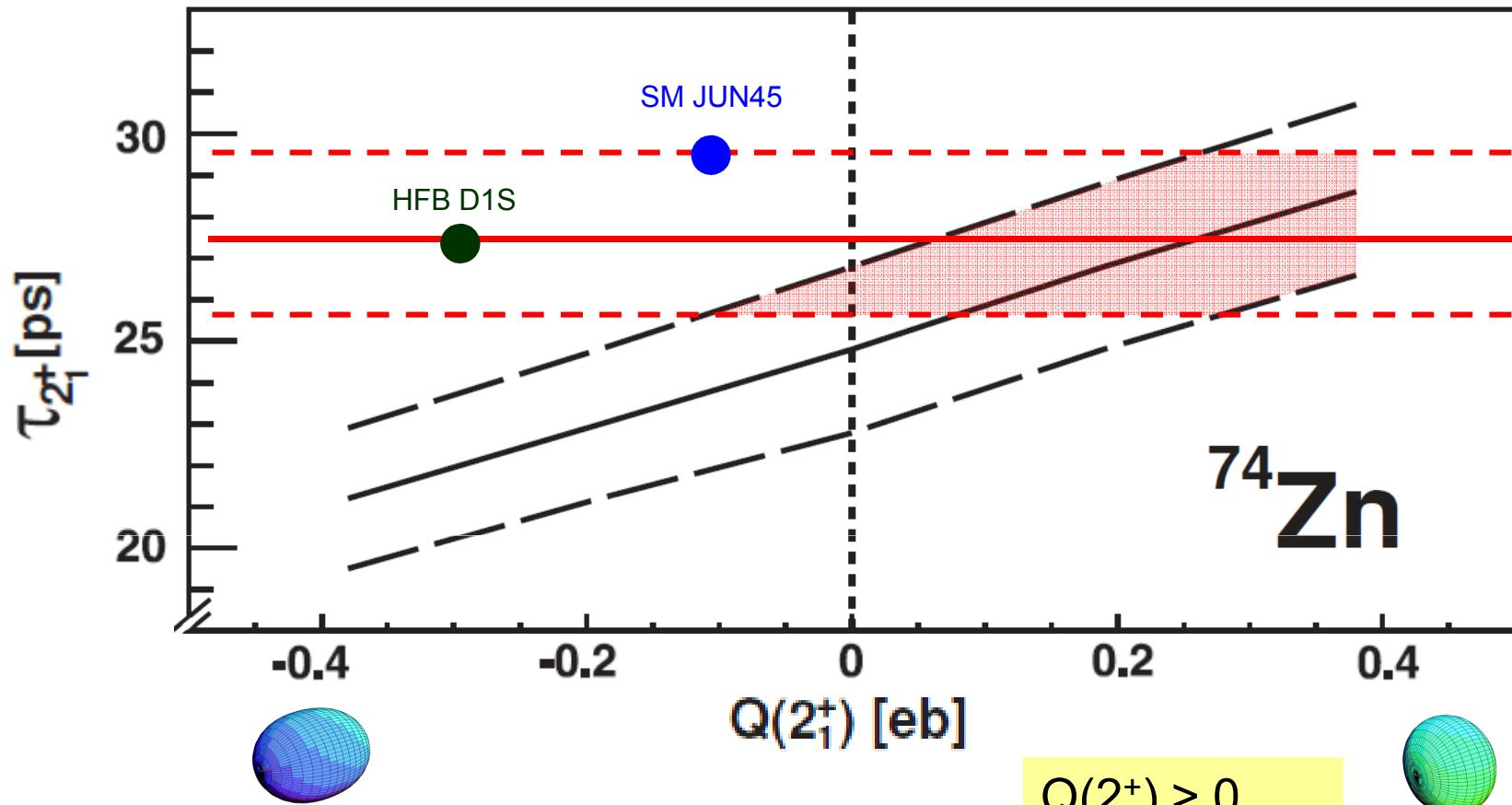
- stable beam
S. Raman, At. Nucl. Data Tab. 78, 1 (2001)
O. Kenn et al. PRC 65, 034308 (2002)
B. Pritychenko arXiv:1102.3365
- intermediate-energy coulex
S. Leenhardt EPJ A 14, 1 (2002)
O. Perru PRL 96, 232501 (2006)
- low-energy coulex
J. Van de Walle PRL 99, 142501 (2007)
J. Van de Walle PRC 79, 014309 (2009)
- RDM after fragmentation
M. Niikura PRC 85, 054321 (2012)
- RDM after multi-nucleon transfer
C. Louchart et al. to be published
- shell model JUN45
M. Honma PRC 80, 064323 (2009)

lifetime measurement:
decay probability depends
on transitional ME only



low-energy coulex:
excitation probability depends on
➤ transitional ME $\Rightarrow B(E2)$
➤ diagonal ME $\Rightarrow Q$
 $B(E2)$ obtained assuming $Q(2^+) = 0$

Combining Coulomb excitation and lifetimes to extract $Q(2^+)$ for ^{74}Zn

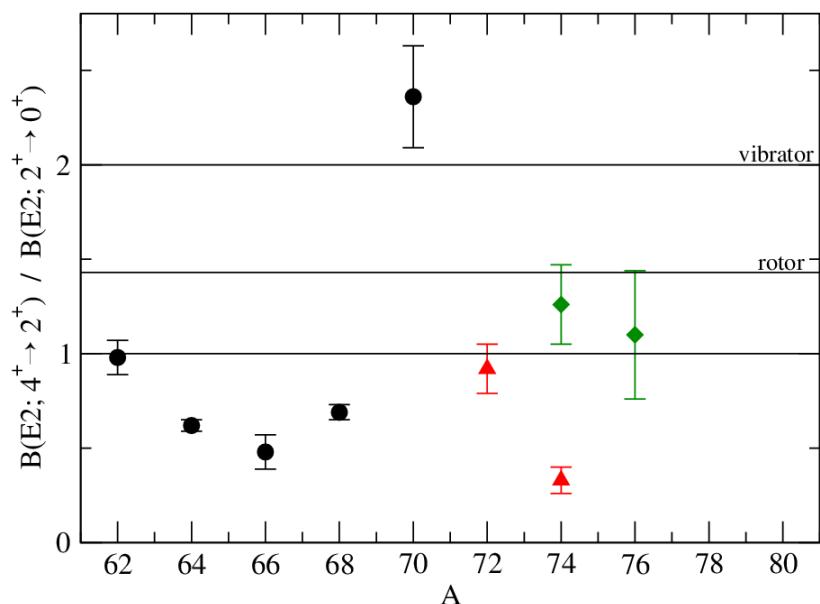
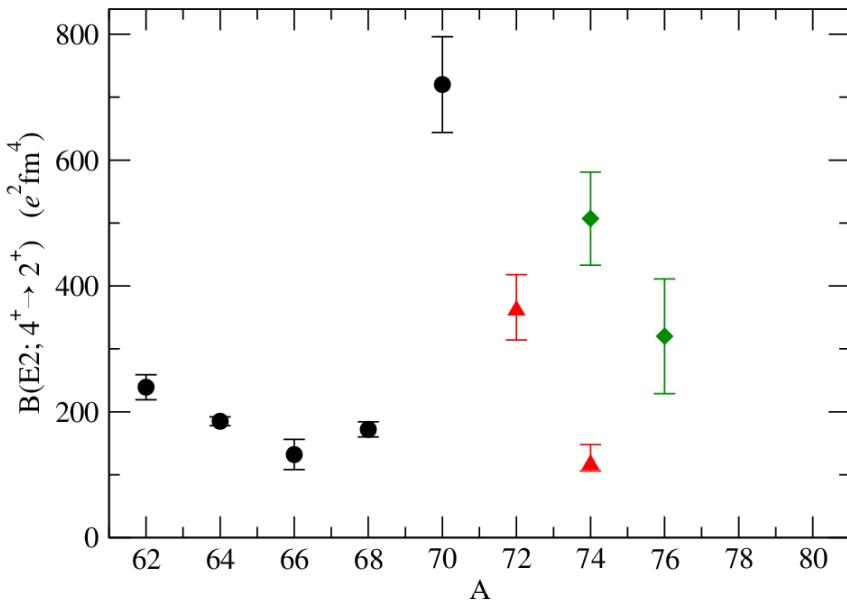


- low-energy Coulex
J. Van de Walle PRC 79, 014309 (2009)

- RDM lifetimes $\tau(2^+)$
after fragmentation: 27.0 (24) ps M. Niikura PRC 85, 054321 (2012)
multi-nucleon transfer: 28.5 (36) ps this experiment (C. Louchart et al.)
weighted average 27.5 (20) ps

$Q(2^+) > 0$
oblate shape

Systematics of $B(E2; 4^+ \rightarrow 2^+)$ values for Zn isotopes



- DSAM lifetimes after Coulomb excitation (combined with g-factor measurement)
O. Kenn et al. PRC 65, 034308 (2002)
- J. Leske et al. PRC 71, 034303 (2005)
- J. Leske et al. PRC 72, 044301 (2005)
- J. Leske et al. PRC 73, 064305 (2006)
- D. Mücher et al. PRC 79, 054310 (2009)
- low-energy Coulomb excitation
J. Van de Walle PRC 79, 014309 (2009)
- lifetimes from present experiment
C. Louchart et al, to be published

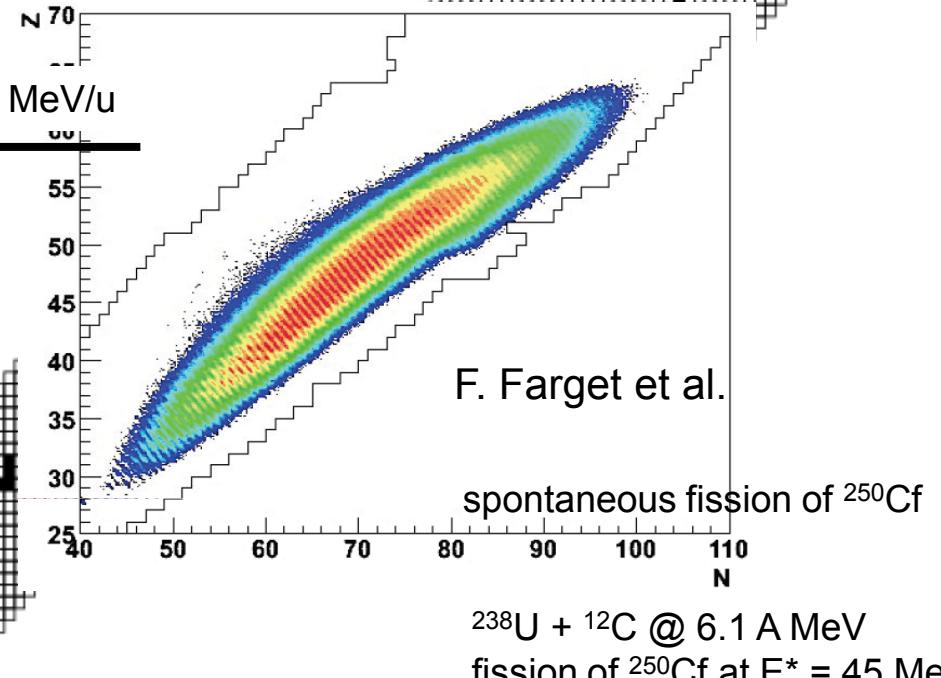
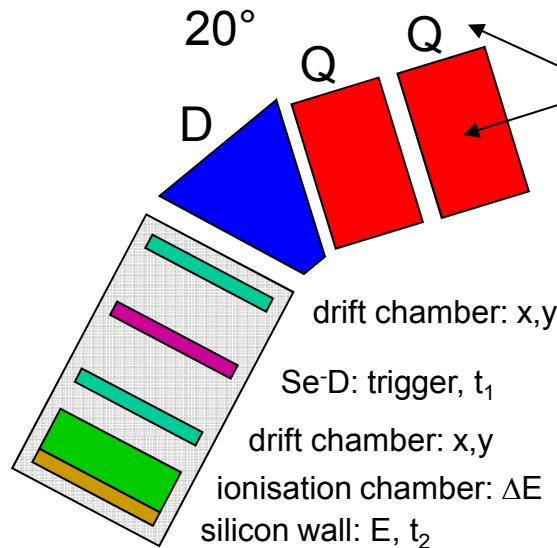
very large $B(E2; 4^+ \rightarrow 2^+)$ in $^{70}\text{Zn}_{40}$

discrepancy between
ISOLDE Coulomb excitation and
lifetime measurement for ^{74}Zn

very small B_{42} ratio for all Zn isotopes
(except for $^{70}\text{Zn}_{40}$)
⇒ non-collective character

Fusion-fission reactions to populate neutron-rich nuclei

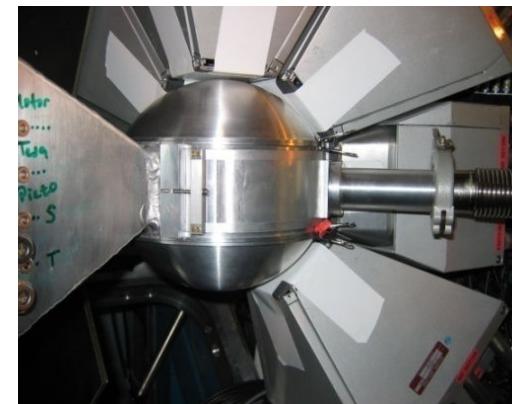
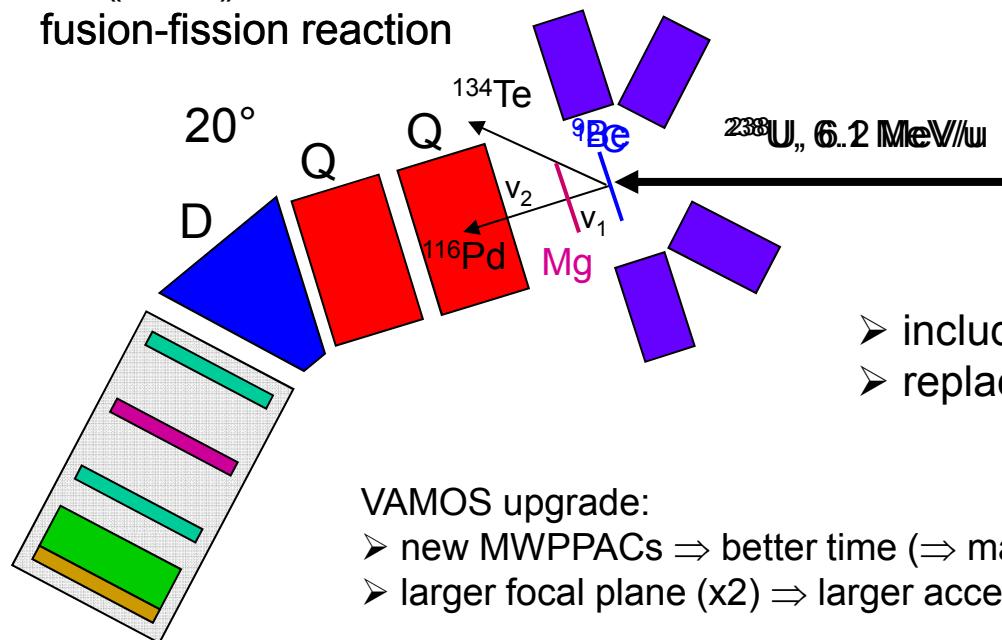
$^{12}\text{C}(^{238}\text{U},\text{f})^{250}\text{Cf}$
fusion-fission reaction



Lifetime measurement in fission fragments

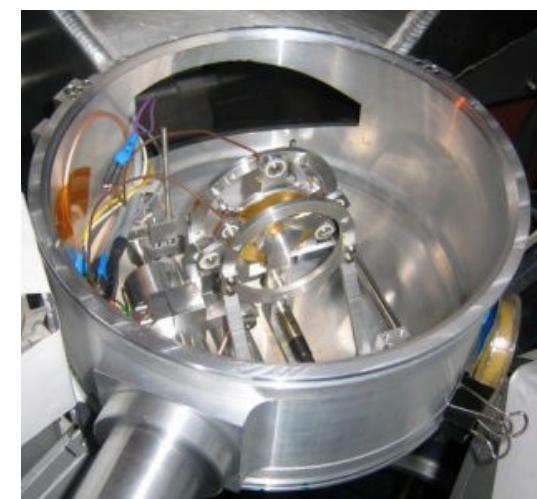
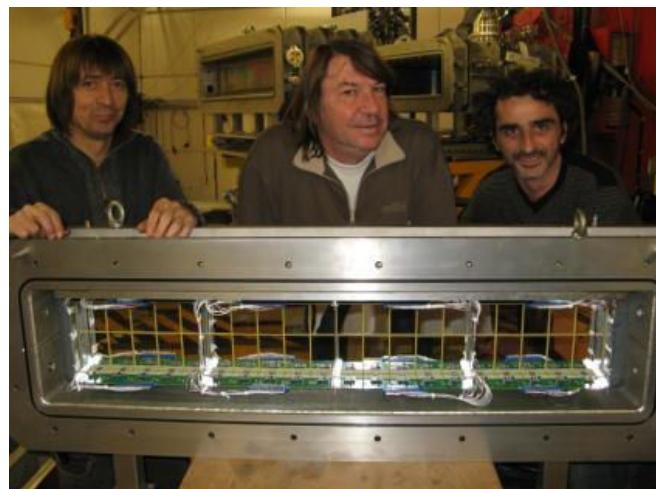


fusion-fission reaction

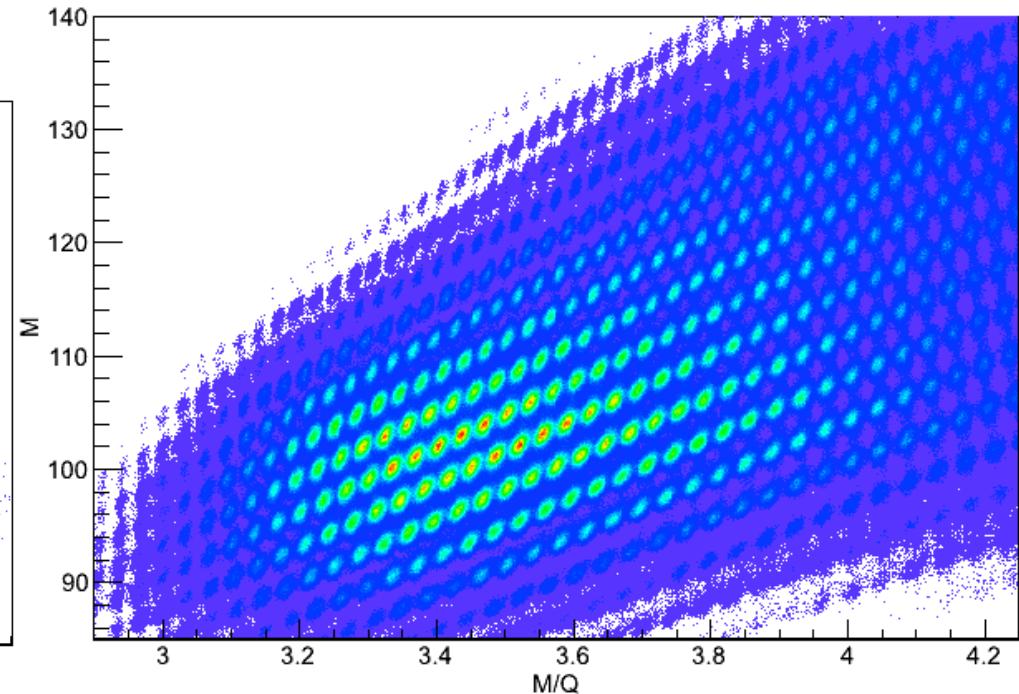
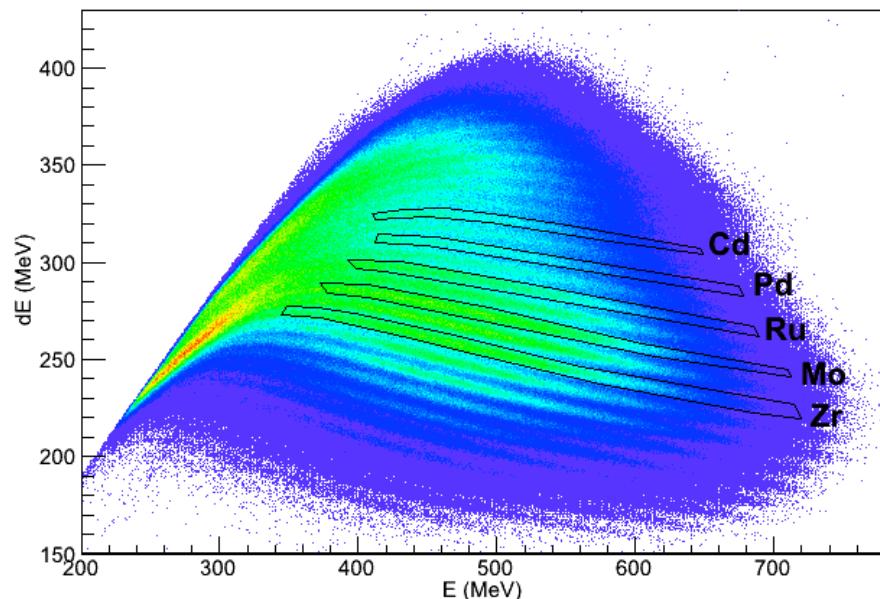


- include plunger
- replace ${}^{12}\text{C}$ with ${}^9\text{Be}$

beam: ${}^{238}\text{U}$ at 6.2 A MeV
 target: 2.3 mg/cm² Be
 degrader: 4.9 mg/cm² Mg
 7 distances 25 – 1600 μm
 24 h per distance



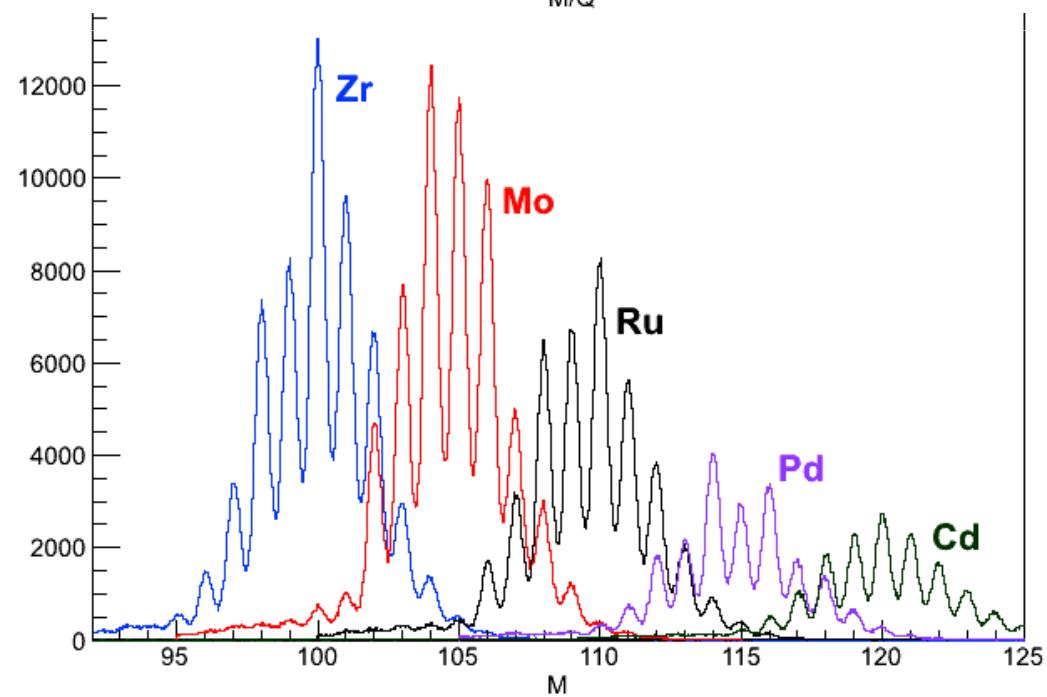
Identification



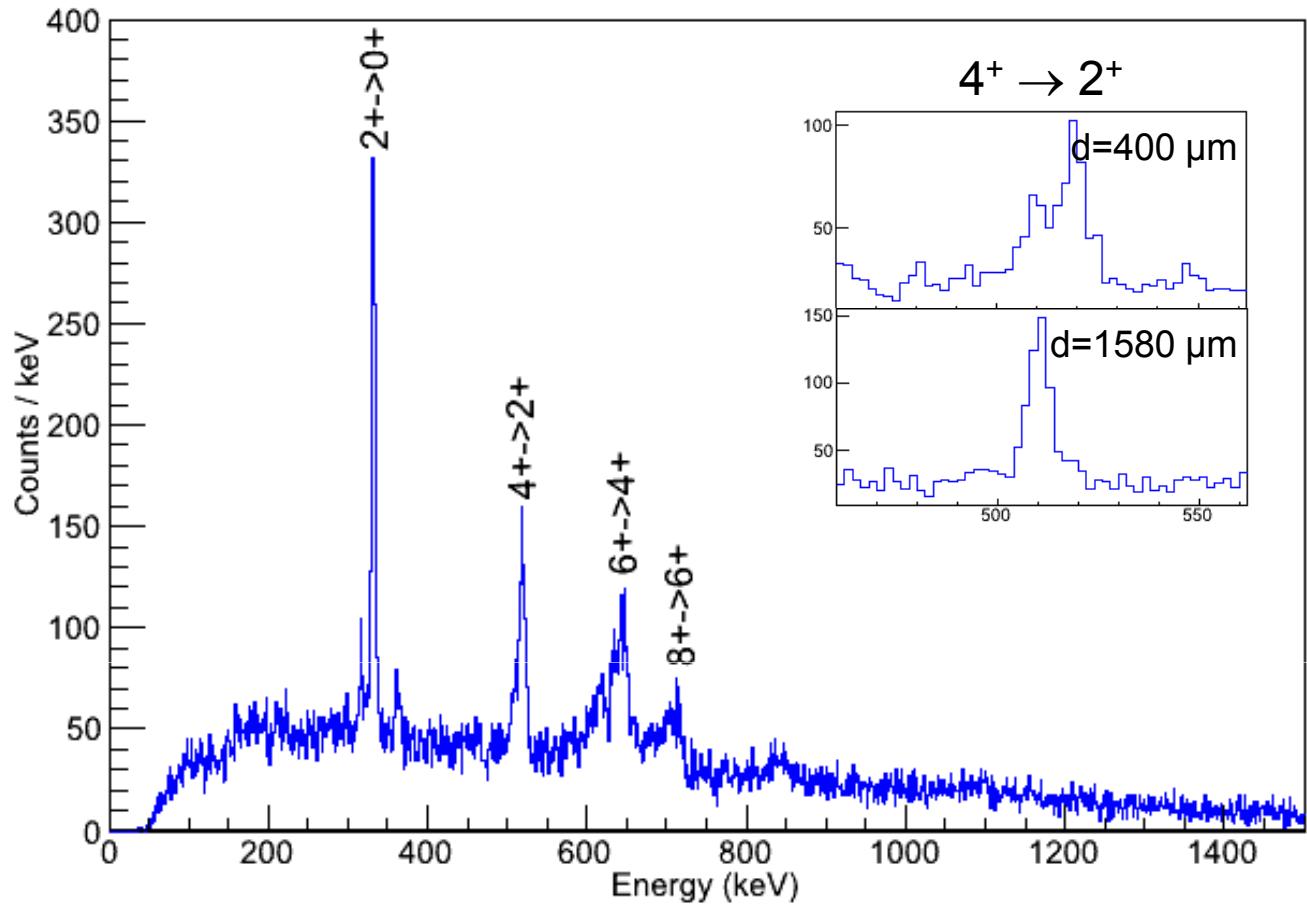
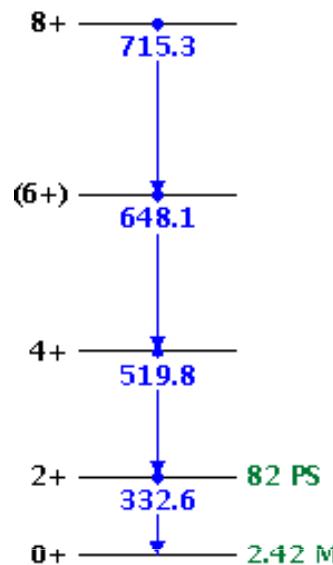
${}^9\text{Be}({}^{238}\text{U},\text{ff})\text{X}$ at 6.2 MeV/u

> 200 neutron-rich isotopes
e.g. ${}^{95-105}\text{Zr}$; ${}^{102-109}\text{Mo}$;
 ${}^{106-115}\text{Ru}$, ${}^{110-120}\text{Pd}$; ${}^{116-124}\text{Cd}$

Trine W. Hagen, Univ. Oslo
Lucie Grente, CEA Saclay

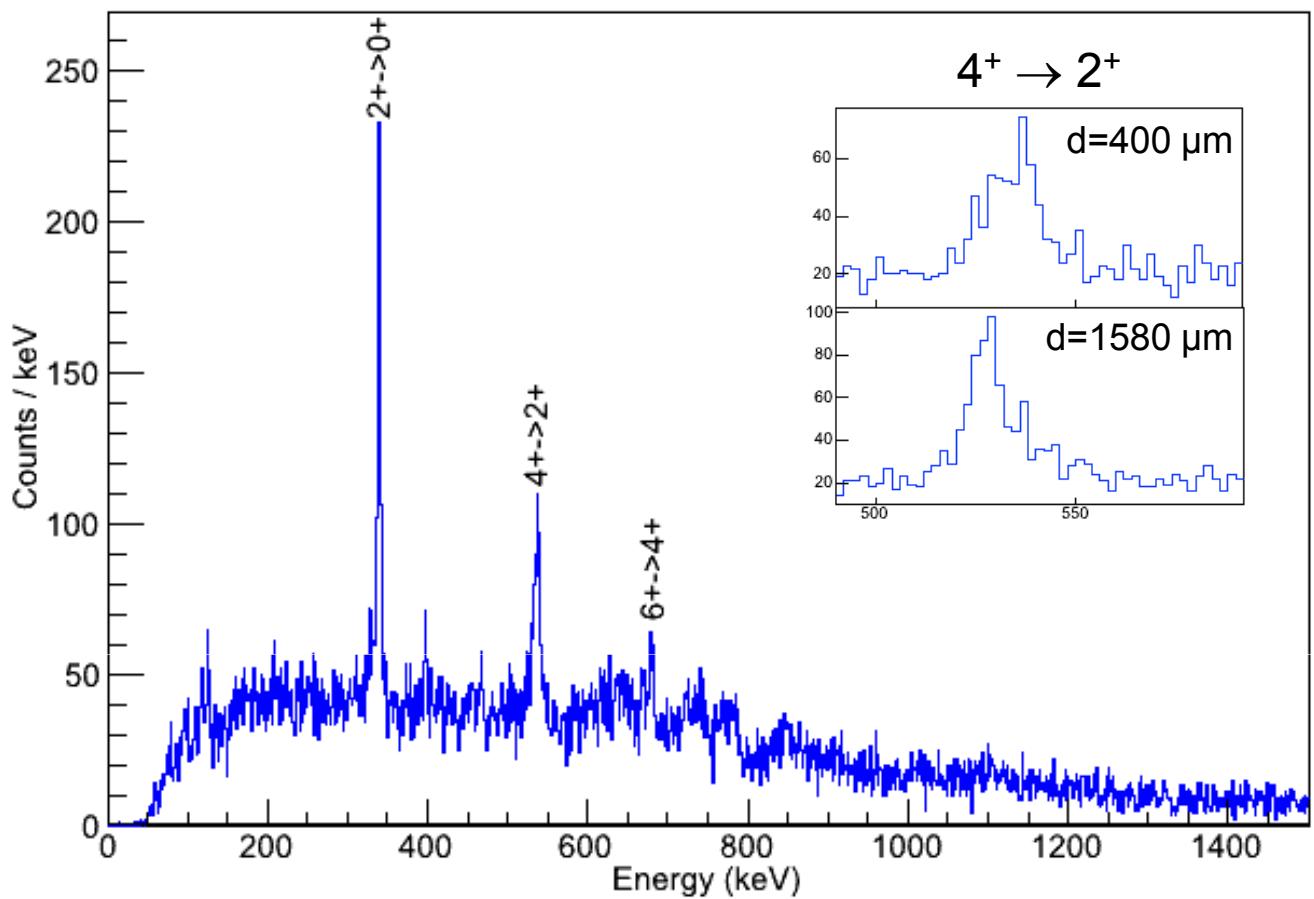
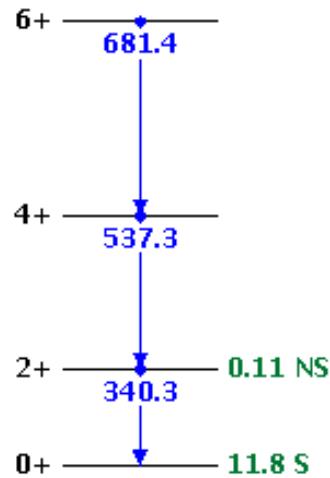


^{114}Pd



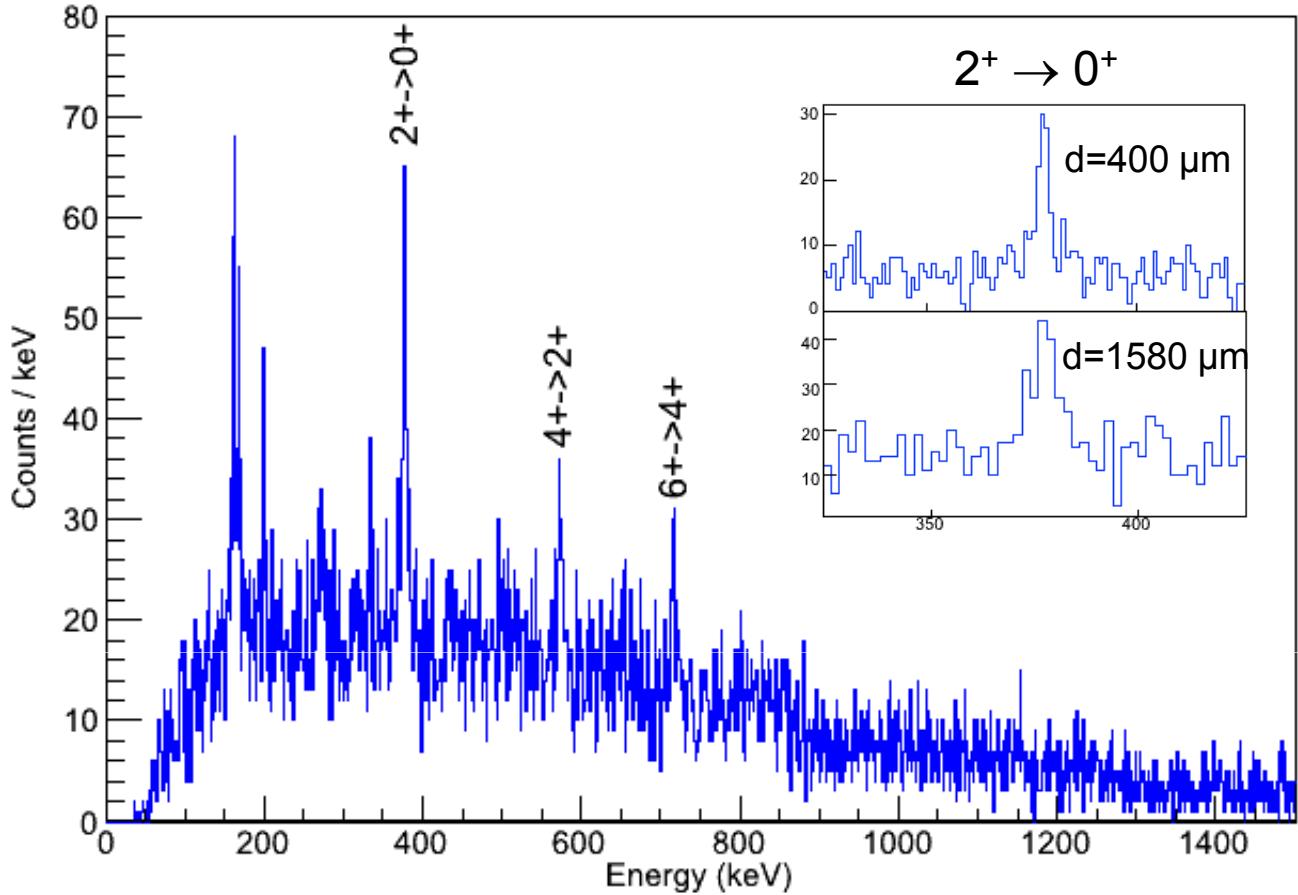
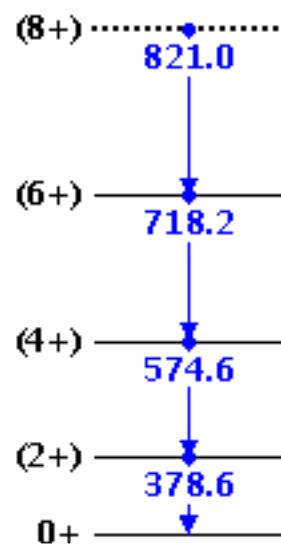
| EC | EC, β^- | 51.839 | EC, β^- | 51.839 | Pd105 | Pd106 | EC, β^- | 51.839 | Pd107 | 5.5E-6 y | Pd108 | 48.161 | EC, β^- | Pd109 | 13.7012 h | Pd110 | β^- | Pd111 | 23.4 m | Pd112 | 21.03 h | Pd113 | 93 s | Pd114 | 2.42 m | Pd115 | 25 s | Pd116 | 11.8 s | Pd117 | 4.3 s | Pd118 | 1.9 s | Pd119 | 0.92 s | Pd120 | 0.5 s | Pd121 | Pd122 | Pd123 | | | | | | | | | | | | | |
|-------|---------------|-----------|---------------|-----------|-----------|-----------|---------------|-----------|--------|----------|---------------|--------|---------------|-------|-----------|--------|-----------|-------|--------|-------|---------|-------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|-------|--------|-------|-------|-------|-------|----|---|-------|----|---|-------|-------|-------|-------|--|
| 0+ | 5/2+ | 0+ | 5/2+ | 0+ | 11.14 | 22.33 | 27.33 | β^- | Rh103 | 42.3 s | Rh104 | 43.2 s | β^- | Rh105 | 35.36 h | Rh106 | 29.80 s | Rh107 | 21.7 m | Rh108 | 6.0 m | Rh109 | 80 s | Rh110 | 3.2 s | Rh111 | 11 s | Rh112 | 2.1 s | Rh113 | 2.80 s | Rh114 | 1.85 s | Rh115 | 0.99 s | Rh116 | 0.68 s | Rh117 | 0.44 s | Rh118 | Rh119 | Rh120 | Rh121 | | | | | | | | | | |
| 11.14 | 22.33 | 27.33 | β^- | β^- | 26.46 | β^- | β^- | β^- | 1/2- * | 100 | EC, β^- | 1+ | * | Rh105 | 29.80 s | Rh106 | 1+ | * | Rh107 | 7/2+ | Rh108 | 7/2+ | Rh109 | 7/2+ | Rh110 | 1+ | * | Rh111 | 1+ | * | Rh112 | 1+ | * | Rh113 | 1+ | * | Rh114 | 1+ | * | Rh115 | 1+ | * | Rh116 | 1+ | * | Rh117 | 1+ | * | Rh118 | Rh119 | Rh120 | Rh121 | |
| 100 | EC, β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | Ru102 | Ru103 | 39.26 d | Ru104 | 4.44 h | Ru105 | 373.59 d | Ru106 | 0+ | Ru107 | 3.75 m | Ru108 | 4.65 m | Ru109 | 34.5 s | Ru110 | 14.6 s | Ru111 | 2.12 s | Ru112 | 1.75 s | Ru113 | 0.80 s | Ru114 | 0.53 s | Ru115 | 0.53 s | Ru116 | Ru117 | Ru118 | | | | | | | | | | | | | | | |
| 31.6 | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | Ru104 | 0+ | 18.7 | Ru105 | 3/2+ | Ru106 | 0+ | Ru107 | 0+ | Ru108 | 0+ | Ru109 | 0+ | Ru110 | 0+ | Ru111 | 0+ | Ru112 | 0+ | Ru113 | 0+ | Ru114 | 0+ | Ru115 | 0+ | Ru116 | Ru117 | Ru118 | | | | | | | | | | | | | | | | | |
| Tc101 | Tc102 | Tc103 | Tc104 | Tc105 | Tc106 | Tc107 | Tc108 | Tc109 | Tc110 | Tc111 | Tc112 | Tc113 | Tc114 | Tc115 | 14.22 m | (9/2)+ | 5.28 s | 1+ | 54.2 s | 5/2+ | 18.3 m | (3+) | 7.6 m | (3/2-) | 35.6 s | (1,2) | 21.2 s | 5.17 s | (2+) | 0.87 s | 0.92 s | 0.30 s | 0.28 s | 130 ms | | | | | | | | | | | | | | | | | | | |

^{116}Pd



| EC | EC, β^- | 51.839 | EC, β^- | Pd106 | Pd107 | 5.6E-6 y | EC, β^- | Pd108 | Pd109 | 13.7012 h | EC, β^- | Pd110 | β^- | Pd111 | Pd112 | Pd113 | Pd114 | Pd115 | Pd116 | Pd117 | Pd118 | Pd119 | Pd120 | Pd121 | Pd122 | Pd123 |
|-------|------------------|------------------|------------------|-----------------|---------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-------------|-------------|-------------|-------|--------|-------|-------|
| 0+ | 5/2+ | 0+ | 5/2+ | 0+ | 0+ | 5/2+ | * | 0+ | 13.7012 h | 5/2+ | * | 0+ | β^- | 23.4 m | 21.03 h | 0+ | 2.42 m | 25 s | 11.8 s | 4.3 s | 1.9 s | 0.92 s | 0.5 s | 0.92 s | 0+ | 0+ |
| 11.14 | 22.33 | 27.33 | | | | | | 26.46 | | | | 11.72 | | | | | | | | | | | | | | |
| Rhl03 | Rhl04 42.5 s | Rhl04 35.36 d | Rhl05 29.80 s | Rhl06 1+ * | Rhl07 7/2+ | Rhl08 6.0 m | Rhl09 80 s | Rhl10 3.2 s | Rhl11 11 s | Rhl12 2.1 s | Rhl13 2.80 s | Rhl14 1.85 s | Rhl15 0.99 s | Rhl16 0.68 s | Rhl17 0.44 s | Rhl18 (7/2+) | Rhl19 1+ * | Rhl16 | Rhl17 (7/2+) | Rhl18 | Rhl19 | Rhl20 | Rhl21 | | | |
| 100 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rul02 | Rul03 39.26 d | Rul03 3/2+ | Rul04 0+ | Rul05 4.44 h | Rul05 3/2+ | Rul06 373.59 d | Rul06 0+ | Rul07 3.75 m | Rul08 4.65 m | Rul09 34.5 s | Rul10 (5/2+) | Rul10 14.6 s | Rul11 2.12 s | Rul11 0+ | Rul12 1.75 s | Rul12 0+ | Rul13 0.80 s | Rul14 0.53 s | Rul15 0.40 s | Rul16 0+ | Rul17 0+ | Rul18 0+ | Rul19 | Rul20 | Rul21 | |
| 31.6 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tcl01 | Tcl02 5.28 s | Tcl03 54.2 s | Tcl04 5/2+ | Tcl05 18.3 m | Tcl05 (3+) | Tcl06 7.6 m | Tcl06 (3/2-) | Tcl07 35.6 s | Tcl07 (1,2) | Tcl08 5.17 s | Tcl08 (2+) | Tcl09 0.87 s | Tcl10 0.92 s | Tcl11 (1+,2+) | Tcl12 0.30 s | Tcl12 0.28 s | Tcl13 130 ms | Tcl14 | Tcl15 | | | | | | | |

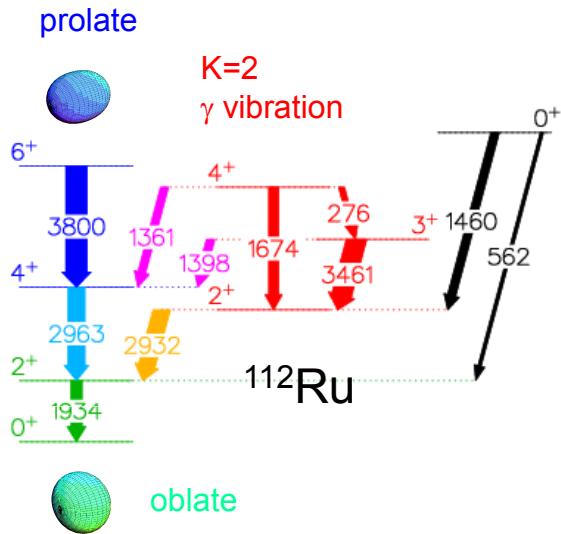
118Pd



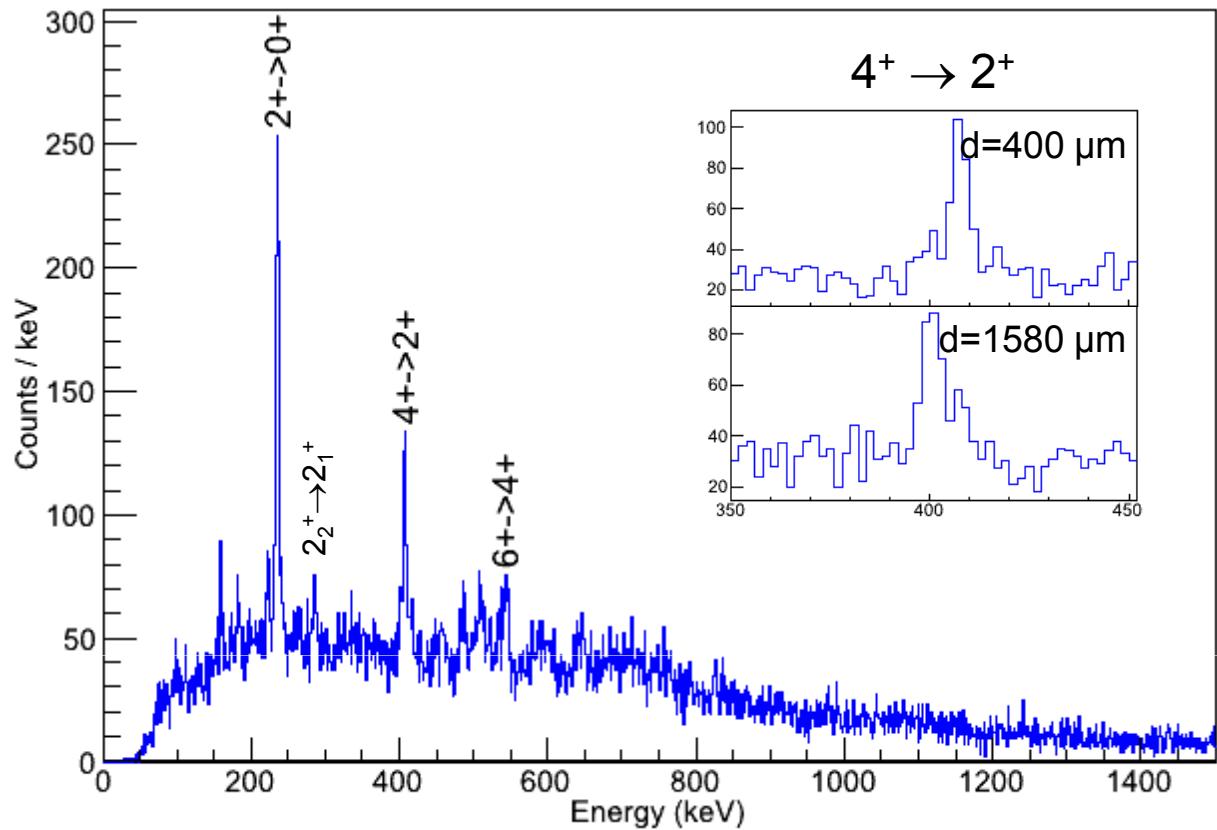
| EC | EC, ^p | SI.339 | EC, ^p | 48.161 | EC, ^p | P ⁻ | P ⁻ | P ⁻ | P ⁻ | P ⁻ | P ⁻ | P ⁻ | P ⁻ | P ⁻ | P ⁿ | P ⁿ | P ⁿ | P ⁿ | P ⁿ |
|----------------------------|------------------|------------------|-------------------|-------------------|--------------------|-----------------|-----------------|------------------|-----------------|-----------------|------------------|-----------------|-----------------|-----------------|----------------|-----------------|----------------|----------------|----------------|
| Pd104 | Pd105 | Pd106 | Pd107 6.5E-6 y | Pd108 | Pd109 13.7012 h | Pd110 | Pd111 23.4 m | Pd112 21.03 h | Pd113 93 s | Pd114 2.42 m | Pd115 25 s | Pd116 (5/2)+ | Pd117 11.8 s | Pd118 4.3 s | Pd119 1.9 s | Pd120 0.92 s | Pd121 | Pd122 | Pd123 |
| 0+ | 5/2+ | 0+ | 5/2+ * | 0+ | 5/2+ * | 0+ | 5/2+ * | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ |
| 11.14 | 22.33 | 27.33 | β- | 26.46 | β- | 11.72 | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- |
| Rh103 | Rh104 42.3 s | Rh105 35.36 h | Rh106 29.80 s | Rh107 21.7 m | Rh108 6.0 m | Rh109 89 s | Rh110 3.2 s | Rh111 11 s | Rh112 2.1 s | Rh113 1.80 s | Rh114 1.85 s | Rh115 0.99 s | Rh116 0.68 s | Rh117 0.44 s | Rh118 | Rh119 | Rh120 | Rh121 | |
| 1/2- * | 1+ * | 1+ * | 1+ * | 7/2+ * | 5(+) | 7/2+ * | 7/2+ * | 7/2+ * | 1+ * | 7/2+ * | 1+ * | 7/2+ * | 1+ * | 7/2+ * | 1+ * | 7/2+ * | 1+ * | 7/2+ * | |
| 100 | EC,β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | |
| Ru102 | Ru103 39.26 d | Ru104 4.44 h | Ru105 3/2+ * | Ru106 373.59 d | Ru107 3.75 m | Ru108 4.55 m | Ru109 34.5 s | Ru110 14.6 s | Ru111 2.12 s | Ru112 1.75 s | Ru113 0.80 s | Ru114 0.53 s | Ru115 0.40 s | Ru116 0+ | Ru117 | Ru118 | | | |
| 0+ | 3/2+ * | 0+ | 3/2+ * | 0+ | 0+ | 0+ | (5/2)+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | 0+ | |
| 31.6 | β- | 18.7 | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | β- | |
| Tc101 14.22 m (9/2)+ | Tc102 5.28 s | Tc103 54.2 s | Tc104 18.3 m | Tc105 7.6 m | Tc106 35.6 s | Tc107 21.2 s | Tc108 (3/2)- | Tc109 (1,2) | Tc110 0.87 s | Tc111 0.92 s | Tc112 (1,+2+) | Tc113 0.28 s | Tc114 130 ms | Tc115 | | | | | |

^{112}Ru

HFB+GCM(GOA) with Gogny D1S
axial and **triaxial** deformation
M. Girod et al.



predictions for $B(E2)$ values [$e^2\text{fm}^4$]



| EC | EC, β^- | 51.839 | EC, β^- | 48.161 | EC, β^- | Pd105 | Pd106 | Pd107 | Pd108 | Pd109 | Pd110 | Pd111 | Pd112 | Pd113 | Pd114 | Pd115 | Pd116 | Pd117 | Pd118 | Pd119 | Pd120 | Pd121 | Pd122 | Pd123 |
|-------------|---------------|------------|---------------|------------|---------------|-------------|-------------|-------------|------------|------------|------------|------------------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|-----------|-----------|---------|
| 0+ | $5/2^+$ | 11.14 | 0+ | 22.33 | $5/2^+$ | Rh103 | Rh104 | Rh105 | Rh106 | Rh107 | Rh108 | Rh109 | Rh110 | Rh111 | Rh112 | Rh113 | Rh114 | Rh115 | Rh116 | Rh117 | Rh118 | Rh119 | Rh120 | Rh121 |
| 11.14 | 22.33 | 27.33 | β^- | β^- | $42.3 \pm$ | $39.26 \pm$ | $35.36 \pm$ | $29.80 \pm$ | $21.7 \pm$ | $6.0 \pm$ | $80 \pm$ | $3.2 \pm$ | $11 \pm$ | $11.5 \pm$ | $2.1 \pm$ | $2.80 \pm$ | $1.85 \pm$ | $0.99 \pm$ | $0.68 \pm$ | $0.44 \pm$ | $0.92 \pm$ | $0.5 \pm$ | $0 \pm$ | $0 \pm$ |
| 100 | | | 1^+ | 1^+ | $42.3 \pm$ | $39.26 \pm$ | $35.36 \pm$ | $29.80 \pm$ | $21.7 \pm$ | $6.0 \pm$ | $80 \pm$ | $3.2 \pm$ | $11 \pm$ | $11.5 \pm$ | $2.1 \pm$ | $2.80 \pm$ | $1.85 \pm$ | $0.99 \pm$ | $0.68 \pm$ | $0.44 \pm$ | $0.92 \pm$ | $0.5 \pm$ | $0 \pm$ | $0 \pm$ |
| Ru102 | Ru103 | Ru104 | Ru105 | Ru106 | Ru107 | Ru108 | Ru109 | Ru110 | Ru111 | Ru112 | Ru113 | Ru114 | Ru115 | Ru116 | Ru117 | Ru118 | Rh119 | Rh120 | Rh121 | | | | | |
| 0+ | $3/2^+$ | 0+ | $3/2^+$ | $4.44 \pm$ | $373.59 \pm$ | $3.75 \pm$ | $0 \pm$ | $4.55 \pm$ | $34.5 \pm$ | $14.6 \pm$ | $2.12 \pm$ | $1.75 \pm$ | $0 \pm$ | $0.80 \pm$ | $0.53 \pm$ | $0.40 \pm$ | $0.53 \pm$ | $0.40 \pm$ | $0 \pm$ | $0.40 \pm$ | $0 \pm$ | $0 \pm$ | $0 \pm$ | $0 \pm$ |
| 31.6 | β^- | 18.7 | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | β^- | |
| Tc101 | Tc102 | Tc103 | Tc104 | Tc105 | Tc106 | Tc107 | Tc108 | Tc109 | Tc110 | Tc111 | Tc112 | Tc113 | Tc114 | Tc115 | | | | | | | | | | |
| $14.22 \pm$ | $5.28 \pm$ | $54.2 \pm$ | $18.3 \pm$ | $7.6 \pm$ | $35.6 \pm$ | $21.2 \pm$ | $5.17 \pm$ | $0.87 \pm$ | $0.92 \pm$ | $0.30 \pm$ | $0.28 \pm$ | 130 ms | | | | | | | | | | | | |
| $(9/2)^+$ | | $5/2^+$ | (3^+) | $(3/2^-)$ | $(1,2)$ | $(2+)$ | | | | | | | | | | | | | | | | | | |

Summary

- RDDS lifetime measurements for neutron-rich nuclei
 - multi-nucleon transfer reactions \Rightarrow moderately neutron-rich nuclei
 - fusion-fission reactions \Rightarrow (very) neutron-rich nuclei
- complementary to Coulomb excitation with RIB
 - populate different states
 - $B(E2) \Leftrightarrow Q_s$
- RDDS lifetime measurement in neutron-rich Zn isotopes
 - $^{76}\text{Ge} + ^{238}\text{U}$ multi-nucleon transfer using PRISMA + AGATA at Legnaro
 - oblate shape for the 2^+ state in ^{74}Zn
 - non-collective character of the 4^+ states
- RDDS lifetime measurement for fission fragments
 - $^{238}\text{U} + ^9\text{Be}$ fusion-fission using VAMOS + Exogam at GANIL
 - simultaneous measurement for wide range of neutron-rich nuclei

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